

THE ASTRONOMERS' WORK.

RESULTS TO SCIENCE OF THE TRANSIT OF VENUS.

THE DIFFICULTIES MET—SIGNIFICANCE OF THE CONTACT OBSERVATIONS—THREE HUNDRED AND FIFTY PHOTOGRAPHS TAKEN—THE OPPOSITION OF MARS IN 1877.

From Our Own Correspondent.
WASHINGTON, Thursday, July 29, 1875.

The observations of the transit of Venus for the purpose of determining the true distance of the sun from the earth, for which costly expeditions were last year equipped and sent out by most of the civilized nations on the globe, do not now promise to correct materially the information before possessed. Just what the expeditions did accomplish, so far as the labors of the American observers are concerned, is given in a statement which your correspondent has obtained from Prof. Harkness, of the Naval Observatory, who was one of the Commissioners of the United States, and also had charge of the party stationed at Hobart Town, in Tasmania. It will be seen that the observations of contacts were not sufficiently successful to admit of the application of the noted method of Halley to the computations, but they may be reduced by the method of De Lisle. There were enough excellent photographs secured to make possible the most accurate computations which can be obtained from that almost untried method of recording astronomical observations. It will be remembered that all the observations of all nations are to be ultimately brought together and used in making the final deductions. But at best the results will never be accepted as conclusive till verified by other and more certain methods of determining the sun's true distance. The following is the statement from Prof. Harkness:

THE STATIONS CHOSEN AND THE WEATHER.

As yet it would be premature to attempt to state definitely what has been accomplished by the transit of Venus expeditions; but the subject has so much intrinsic interest that a brief survey of it cannot be otherwise than attractive. We will consider only the American expeditions, of which there were eight. Those in the Northern Hemisphere being stationed at Wladivostok, Siberia; Pekin, China, and Nagasaki, Japan; and those in the Southern hemisphere at Kerguelen Island; Hobart Town and Campbell Town, Tasmania; Queenstown, New Zealand, and Chatham Island.

Many of these are such out-of-the-way places that the question naturally arises, how came they to be chosen. The answer is simple. To see the whole transit each observer had to be so situated that the sun would be above his horizon all the time that Venus was on its disk. This limited the stations to a region which may be defined generally as comprehending Asia and that part of the Pacific Ocean in which the Australian islands lie. Again, the distance of the sun was to be measured by means of a triangle, and to get a long base line it was desirable to put the northern observers as far north, and the southern observers as far south, as possible. Finally, the success of the observations was dependent upon the sky being clear at the critical time, and on that account it was necessary to select those points which usually have the largest percentage of clear weather in December. Upon examination it was found that at the season in question the weather was usually so much better in the northern hemisphere than in the southern that to equalize the chances of obtaining observations in these two regions it would be necessary to send five parties to the southern and only three to the northern one. These were the conditions which led to the choice of the stations already mentioned.

The commission to whom the arrangement of the expeditions was intrusted naturally supposed that on the day of the transit clouds would prevail at some of these places to such an extent as to preclude all observations, while at others the sky would probably be clear enough to permit the continuous observation of Venus during the whole of her passage across the sun. However, these anticipations were not realized. On the contrary, the entire earth seems to have been involved in broken, drifting clouds; and, strangely enough, although all the American stations suffered from them, still there was not one at which some observations were not obtained.

METHOD OF FINDING THE SUN'S DISTANCE.

It will assist us in estimating the value of the results achieved at these stations if we consider for a moment the nature of the problem attacked. If a person sitting at the back of a room looks out of the window he will see the window bar projected against the house on the opposite side of the street. Now, without removing his eyes from the window, let him rise from his chair and the window bar will appear to sink to a lower position on the opposite house. In the same way when Venus was passing between the earth and the sun she appeared nearer the sun's northern limb to the observers at the southern stations than to those at the northern ones. The object of the expeditions was to measure the exact amount of this displacement, and it was proposed to effect this by two different methods, known respectively as the Photographic method and the Halleyan. To fix our ideas, let us consider only one northern and one southern station. If at both these stations photographs of the sun are taken at short intervals during the whole of the transit they will furnish the means of laying down the two paths of the planet over the sun's disc, as seen respectively from the two stations, and the distance between these paths can be measured with very little trouble. This is the photographic method. Again, as the velocity with which Venus appears to move is nearly constant all the world over, it follows that the time occupied in her transit will be a measure of the length of her path on the sun's disc. Hence, if at each station we note accurately the time when she enters on and leaves the sun's disc, we have the means of computing the length of the two paths required, and by laying them down on a drawing of the sun we can find their distance apart as before. This is the Halleyan method. Of course, in the actual use of these methods as many stations as possible are employed, and numerous small corrections have to be taken into account, which make the computation very difficult and laborious. But enough has been said to enable the reader to comprehend the principle of the methods.

THE SUCCESS OF THE AMERICAN EXPEDITIONS.

The number of photographs taken was as follows: At Wladivostok, thirteen; at Pekin, ninety; at Nagasaki, sixty; at Kerguelen, twenty-six; at Hobart Town, thirty-nine; at Campbell Town, fifty-five; at Queenstown, fifty-nine, and at Chatham Island, eight. That is, there was 163 pictures taken in the northern, and 137 in the southern hemisphere, making a total of 350. On the whole, this is a tolerably satisfactory result, especially as the pictures are quite evenly distributed between the two hemispheres; but if the weather had been fine about three times as many would have been obtained. These numbers refer only to pictures taken while Venus was completely within the disc of the sun. In addition, about 250 others were obtained in which Venus appears only as an indentation in the edge of the sun.

THE OBSERVATIONS OF CONTACTS.

Before passing to the observations made according to the Halleyan method, it may be remarked that the instant when Venus first touches the sun's edge is technically called the first contact. Passing gradually onto the face of the sun his light finally closes around her, and she appears as a black dot upon his face. The instant when this takes place is the second contact. After traversing the sun's disc, the black dot arrives a second time at his edge, which is the third contact, and finally at the fourth contact it passes entirely off.

The contacts observed at the American stations were as follows: At Wladivostok, the first, second, and third; at Pekin, all four; at Nagasaki, the first and second; at Kerguelen Island, the first only; at Hobart Town, none; at Campbell Town, the third; at Queenstown, the first and second; and at Chatham Island, none. Although both the second and third contacts were observed at two northern stations, still, as this was not done at any southern station, they cannot be used according to the Halleyan method. Fortunately it will be possible to utilize them by employing a somewhat different system of reduction known as De Lisle's method. However, the comparative failure in obtaining contact observations is probably not a matter of very serious importance, because the experience of these astronomers, who were favored with the best weather last December,

renders it at least questionable if the atmosphere of Venus does not impair the accuracy of those observations to such an extent as to render them almost worthless for determining the solar parallax. The preliminary results lately published by the French commission seem to strengthen this view of the case, for, although some of the contact observations give satisfactory values of the parallax, others give values which are evidently quite erroneous.

IMPORTANCE OF THE PHOTOGRAPHIC METHOD.

Under these circumstances it is not unlikely that the value of the transit of last December as a means of finding the sun's distance will depend entirely upon the accuracy of the results given by the photographic method. Within the last few years a great deal has been written about astronomical photography, but unfortunately the results obtained from actual use of the method have never been so discussed as to show conclusively the degree of accuracy it will afford. It is hoped that the American photographs will give the distance of the sun within 200,000 or 300,000 miles of the truth, but it is needless to deny that the uncertainty of the result may be considerably greater. It will take some months to read off these photographs and submit them to rigorous computation, but until that has been done any opinion as to their accuracy will be mere guess-work.

THE TRANSITS OF VENUS GIVE UNSATISFACTORY RESULTS.

For more than two centuries almost all astronomers have held that transits of Venus are by far the best method of determining the sun's distance, but it is at least questionable if this opinion is borne out by the observations made last December. Until then no astronomer of the present age had seen Venus upon the sun's disk, and, perhaps, the very rarity of the phenomenon gave it an importance and enshrouded it with a glamour which was not its own; but now that it has been studied by the aid of all the appliances which modern science can bring to bear upon it, we can form a better estimate of its actual worth. Let us compare it with another phenomenon which occurs somewhat more frequently, and which is also used to measure the sun's distance.

ADVANTAGES OF THE OPPOSITION OF MARS.

The planet Mars is nearest the earth when in the position technically known as "opposition," but its orbit is so eccentric with respect to our own, that at some oppositions it is almost twice as far off as at others. It so happens that in September, 1877, an opposition will occur, when its distance from the earth will be almost the least possible, and, of course, this will be a peculiarly favorable opportunity for measuring its parallax, and thus determining that of the sun. This is the phenomenon which we are to compare with the last transit of Venus.

The localities from which the transit was visible were in parts of the world where there are few or no fixed observatories, and consequently the observations had to be made with portable instruments, by field parties sent out specially for the work. No one who has had any experience in such matters needs to be told of the numerous difficulties incident to such expeditions. The opposition of Mars will be visible from all parts of the world, and consequently it can be observed at the fixed observatories with the largest and best instruments known to astronomers. The transit of Venus lasted but little more than five hours, and at any station where the sky was cloudy during those few precious moments the observation was irretrievably lost; but during the opposition Mars will be so situated that he can be observed every night for at least a month, and it is very unlikely that bad weather will prevail all that time. Again, Venus had to be observed upon the face of the sun, which is about the worst possible position for delicate work, because the solar heat generally disturbs the earth's atmosphere so much as to destroy all possibility of fine definition in the telescope; but Mars will be observed at night, when the atmosphere is quiet and everything is in the most favorable condition for good seeing. Thus far the comparison has been entirely in favor of Mars, but in the only remaining point, and it is a very important one, Venus has the advantage. The parallax of Venus at her transit was thirty-three and a half seconds; but, as the observations were differential, we must deduct from this nine seconds for the solar parallax, which leaves twenty-four and a half seconds as the angle to be measured. In the case of Mars the angle will be only twenty-three and a half seconds, which is four per centum less than that for Venus; but, unless the photographs of the transit can be measured with very great accuracy, the knowledge we now possess would lead us to infer that this disadvantage will be more than counterbalanced by the other circumstance mentioned above. On the whole, it seems not unlikely that the observations of Mars in September, 1877, will give more accurate results than those of Venus in December, 1874; but this is a state of affairs which could not have been anticipated a year ago; and, moreover, the transit was so important a phenomenon that unless every effort had been made to utilize it to the utmost, the astronomers of this age would not have been held blameless by their successors.